AMEREN MISSOURI LABADIE ENERGY CENTER

LABADIE SULFUR REDUCTION PROJECT

STANDARD OPERATING PROCEDURE

TELEDYNE ADVANCED POLLUTION INSTRUMENTATION

MODEL 701
ZERO AIR MODULE

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August 2014

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1. INSTRUMENT OVERVIEW

The Teledyne Advanced Pollution Instrumentation Model 701 dries and scrubs ambient air to produce zero air.

The compressor draws air in from the rear panel bulkhead union and inlet filter. At the compressor outlet, the air is under pressure and hot from the compression. The relative humidity is high as a result of the high pressure. The air is conducted through the cooling coil where heat is removed by transfer to the cooling fan air. With the pressure still high but the temperature reduced to ambient, the relative humidity is at its highest. At this point, the air is usually supersaturated.

From the coil, the wet air passes through a coalescing filter where the excess water is separated and settles in the bottom of the filter. The controller periodically opens the solenoid drain valve allowing the water to be expelled through a rear panel bulkhead union (drain). The partially dried air passes a pressure relief valve, set to open at 90 psig, and enters the regenerative scrubber which removes essentially all the remaining water and a portion of the other contaminants.

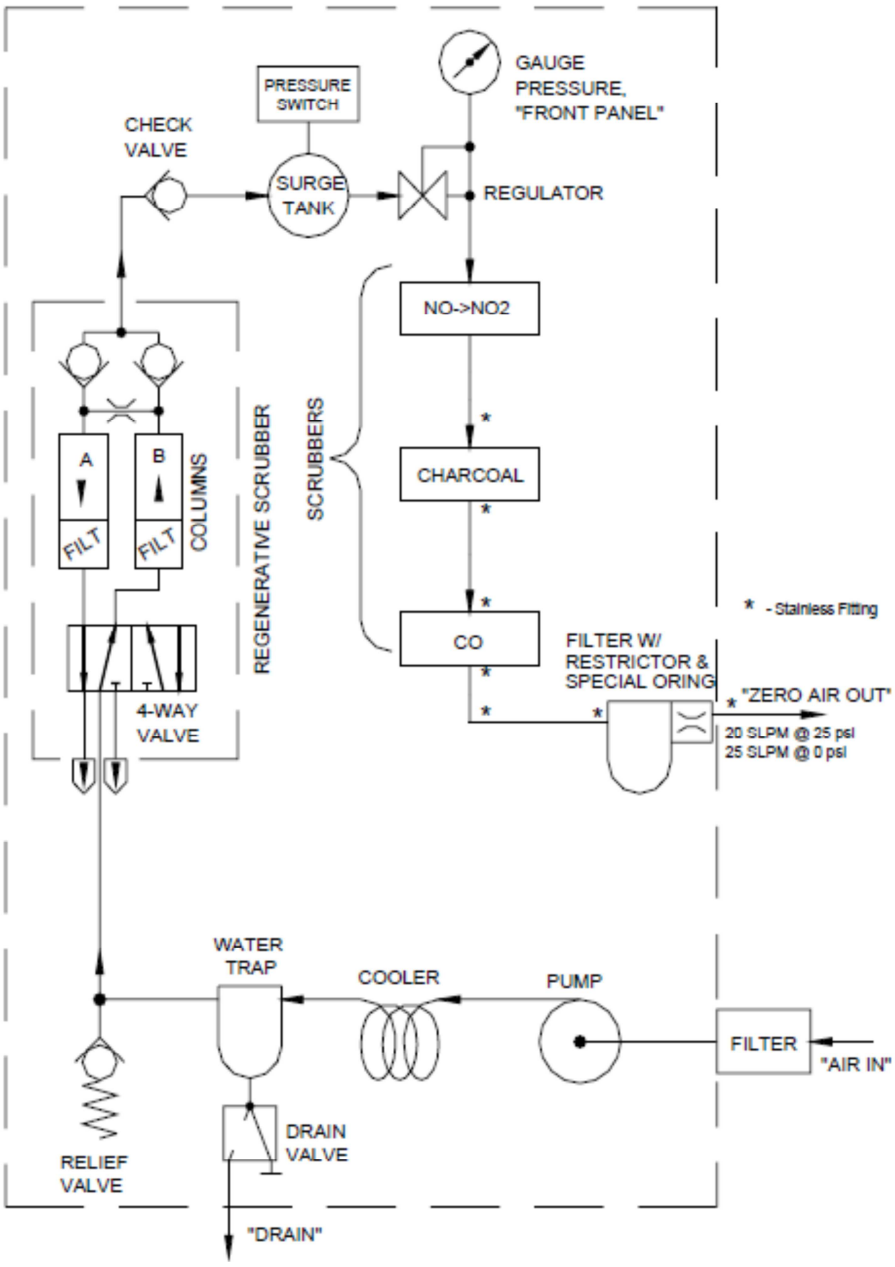
The dry air then passes through a check-valve to the storage tank. A pressure switch turns off the compressor when the pressure in the tank reaches a set high value, and turns the compressor on when the pressure reaches a set low value. Thus, when air demand is low, the compressor is turned off and the tank fulfills the demand. The pressure in the tank varies from approximately 35 psig to approximately 75 psig depending on the demand. As the air leaves the tank, its pressure is controlled to 35 psig by an air pressure regulator mounted on the front panel. This maintains a constant pressure at the calibrator inlet and is displayed by the pressure gauge on the 701 front panel.

For a final clean-up, the dry, regulated air enters the specific scrubbers:

Dry, regulated air enters the NO scrubber where NO is oxidized to NO2, then, the activated charcoal scrubber where the NO2 is absorbed. Finally, the clean dry air passes through a fine particulate filter and leaves the 701 through the rear panel bulkhead union (Zero Air Out).

When air usage is high (say 5-20 LPM), the compressor runs continuously. When air usage is low, the pressure switch turns the compressor off until the storage tank pressure drops to 35 psig, then turns the compressor on again. There is no need for the user to turn off the 701 when air usage is low.

Figure 1: Pneumatic Diagram of M701



2. INSTRUMENT DESCRIPTION

The instrument is more easily described by separating it into its main components.

2.1 Compressor

The compressor is a two-cylinder oscillating piston type driven by a split capacitor AC motor. The compressor is dry; that is, there are no lubricants which can contaminate the compressed air. The pistons are sealed by flexible TFE piston rings, and after a short run-in period to seat the rings, should last for years. There are no diaphragms.

The compressor is mounted on a sub-plate which is supported on four tuned vibration isolators. During shipment, the sub-plated is bolted firmly to the chassis. The shipping screws must be removed prior to starting the 701.

2.2 Cooling Coil

The cooling coil consists of several turns of copper tubing coiled to form a cylinder through which the cooling fan blows outside air.

2.3 Water Trap

The water trap is a coalescing type. Supersaturated air enters the trap and is rapidly swirled causing the water droplets to deposit on a membrane where the drops coalesce and gather in a puddle at the bottom of the filter bowl.

2.4 Water Drain Valve

Accumulated water is drained from the filter through a stainless steel solenoid-operated valve. The valve is sequenced by the controller and is open for approximately 2 seconds every hour. The water/air spray leaving the rear panel water out fitting is in high velocity spurts and should be appropriately conducted away from any sensitive components. The operation cycle has been preset at the factory and is not adjustable.

2.5 Pressure Relief Valve

The pressure relief valve is a safety device designed to limit the maximum pressure to which the 701 can be subjected. It is set to open at 90 psig.

2.6 Regenerative Scrubber

The regenerative scrubber consists primarily of two parallel columns of molecular sieve, in which alternately one column is scrubbing the air while the other is being regenerated. The regenerative scrubber needs no warm-up and operates at full efficiency as soon as the 701 is turned on. The molecular sieve is not consumed and is good for the life of the instrument.

When the 701 is turned on, a four-way solenoid-operated valve directs high pressure air to one of the two columns and vents the other column to atmosphere. Virtually all the water in the high-pressure air is trapped by the molecular sieve. A portion of the dried air is expanded to atmospheric pressure in the outlet shuttle valve and passes in reverse through the second column. By expanding the air, the volume increases and the relative humidity decreases thus enabling a small amount of dry purge air to evaporate the entrained water in the second column. The wet purge air leaving the column is exhausted inside the 701. The rapid air movement inside the 701 chassis ensures that the small amount of water involved is safely vented to the atmosphere. The majority of the dry air from the first column is conducted to the storage tank.

The controller toggles the four-way valve every 2 minutes and the columns alternate their function. This cycling rate has been selected to provide the optimum balance of scrubbing efficiency and air usage and is not adjustable.

2.7 Check Valve

The purpose of the check valve is to isolate the air in the storage tank from the components upstream. Thus when the compressor turns off, the air in the storage tank will be retained and not lost through the drier purge air path or back through the compressor.

2.8 Storage Tank

The storage tank serves two functions. As its name implies, it stores air so that when the demand is low, the compressor can be turned off to conserve energy, allowing the storage tank to supply the air requirements. The tank also serves as "filter capacitor", preventing pulses generated by the drier cycles or water drain valve from reaching the output port on the rear panel.

The air in the tank has been dried so there is no need for a tank drain and no concern about internal corrosion. The tank is a commercial gas storage cylinder, rated at 1800 psi, and is not modified or altered in any way that can harm its integrity.

2.9 Pressure Switch

The pressure switch senses the pressure in the storage tank. It is set at the factory to turn off (cut out) the compressor at 75 psig and to turn the compressor on (cut in) at 35 psig. The pressure switch controls the compressor through the control board.

2.10 Pressure Regulator

The Model 700 calibrator requires that its air source be stable and not subject to compressor-induced pressure surges or pressure variations with flow. The pressure regulator serves this function. It is set at 35 psig at the factory. Should adjustment be desired, the regulator is accessible on the front panel. The adjustment knob has a push-pull locking ring which should be reengaged after making an adjustment to prevent the knob from turning under vibration. When used with the Teledyne API Model 700 Calibrator, the pressure should be between 30 and 35 psig.

2.11 Pressure Gauge

The front panel-mounted pressure gauge shows approximately the regulated air pressure available to a calibrator. The gauge will usually indicate 30 psig. If the flow is very low, as in a standby condition, the gauge may read a little higher, say 33 psig. It will move to the correct reading when the air flow is increased. If the pressure drops below 30 psig, it may be because too much air is being commanded. At maximum air flow, 20 SLPM, you may notice that the pressure drops to 29 psig. This is normal.

2.12 NO Scrubber

The NO scrubber uses Purafil® to oxidize NO to NO2. Purafil® has a finite life and should be replaced every six months or sooner if the level of NO in the air is high.

2.13 Charcoal Scrubber

Activated charcoal removes NO_2, O3, SO_2 and H_2S. The charcoal should be replaced every six months or sooner if there are high atmospheric levels of these contaminants, or if the calibrator zero air shows signs of a positive drift.

2.14 CO Scrubber

The CO scrubber catalytically oxides CO to CO_2. The catalyst is proprietary and operates at room temperature; however it is heated to approximately 70°C to prevent water condensation. It theoretically should never need changing. However, it may become contaminated or poisoned over time so it should be replaced once per year or sooner if the level of CO in the air is high.

2.16 Final Filter

The final filter, inside the rear panel retains any particulates released by the 701. The filter rating is 10 microns. If the filter should become restricted, it should be disassembled and cleaned, or the element replaced.

2.17 Controller

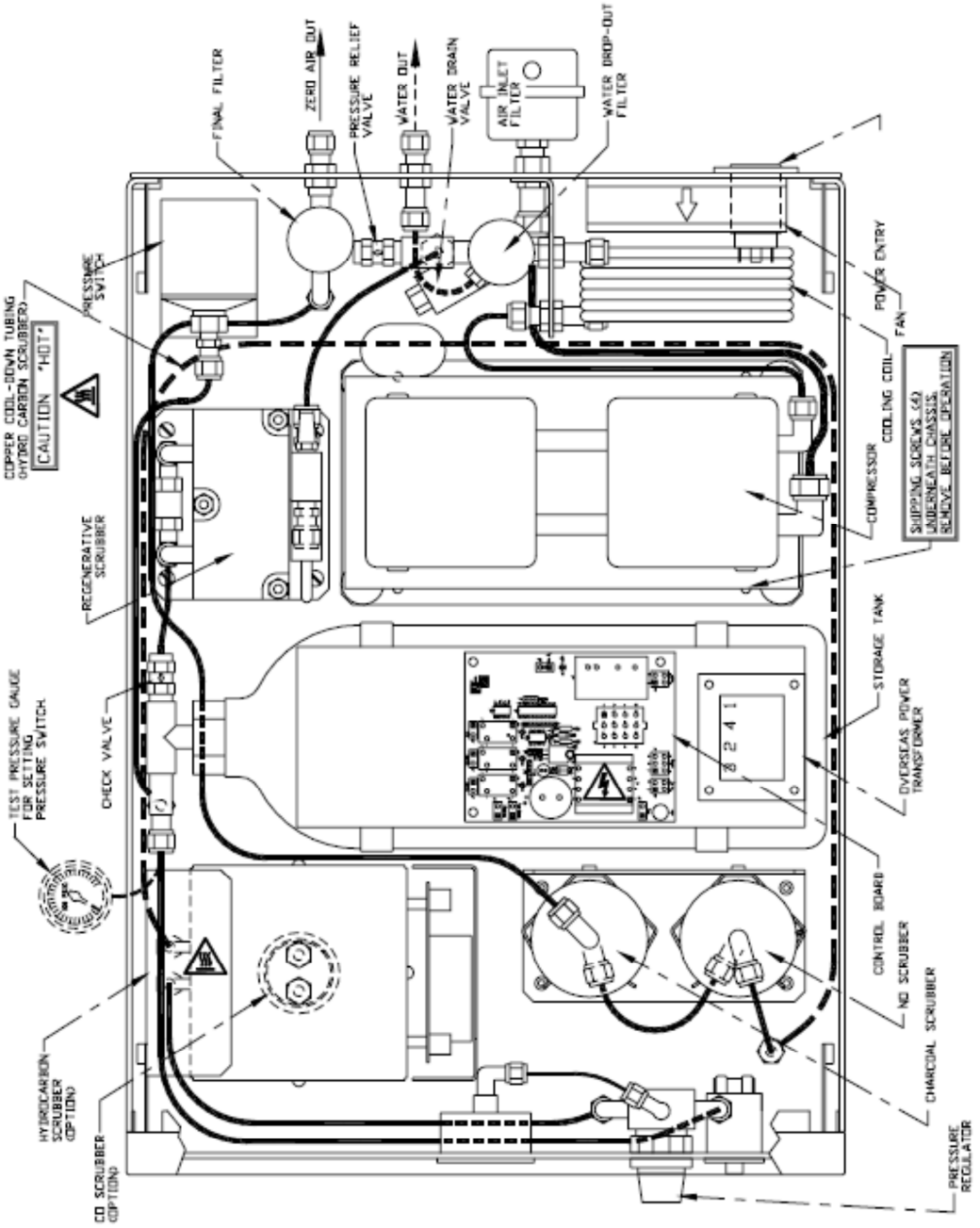
All functions of the 701 are managed by the 701 Control PCB. The 701 Control PCB provides connections for all switched and non-switched AC components, AC input, and the front panel power switch/circuit breaker. Non-switched components include the HC scrubber, fan and front panel power indicator. Switched components include the regenerative scrubber valve, water drain valve, and the pump. Additionally, the tank pressure switch is connected to the PCB. Provision for 120v/240v AC power is via a jumper plug/autotransformer connector (J2). All connections are made by quick release electrical connectors to aid in servicing. See Figure 4-4, Figure 4-5 and Interconnect Drawing in Appendix A of the Model 701 Operation Manual.

The 701 Control PCB is microcontroller based, and all timing is derived from the AC line. It automatically senses the line frequency (50/60 Hz) and provides the following functions:

1. Cycles the four-way valve of the regenerative scrubber at 2 minute intervals.
2. Cycles the water drain solenoid valve at 60 minute intervals.
3. Starts and stops the compressor in response to the pressure switch. This function includes cycling the regenerative scrubber four-way valve and momentarily opening the water drain solenoid valve before starting the compressor. This momentarily reduces the pressure at the compressor outlet to facilitate compressor starting.

LED D7 (see Figure 4-5) flashes at 1 second intervals as an indication that the controller is functioning, and a watchdog timer is enabled to prevent any power line disturbances from halting the processor.

Figure 2: Layout of Internal Components



3. INSTALLATION AND SET-UP

3.1 UNPACKING

Unpack the instrument according to the guidelines presented in Chapter 1 of the Operation Manual. Verify that there is no apparent external shipping damage. If damage has occurred, please advise the shipper first, then Teledyne API.

With no power to the unit, carefully remove the top cover of the analyzer and check for internal shipping damage by carrying out the following steps:

a. Remove the locking screw located in the top, center of the front panel;
b. Remove the two flat head, Phillips screws on the sides of the instrument;
c. Slide the cover backwards until it clears the analyzer's front bezel, and;
d. Lift the cover straight up.
e. Inspect the interior of the instrument to ensure that all circuit boards and other components are in good shape and properly seated.
f. Check the connectors of the various internal wiring harnesses and pneumatic hoses to ensure that they are firmly and properly seated.
g. Verify that all of the optional hardware ordered with the unit has been installed. These are listed on the paperwork accompanying the analyzer.
h. Remove the red shipping screws holding the compressor base. These screws are underneath the chassis.

3.2 ASSEMBLY AND SYSTEM INTEGRATION

3.2.1 Assembly and Installation

Assemble the instrument according to the guidelines presented in Chapter 1 of the TAPI 701 Operation Manual. The PAMS monitoring station design calls for rack-mounting of the analyzer. Install the male parts of the supplied slide rails on the sides of the analyzer and the corresponding female parts of the rail slides in the instrument rack. Ensure there will be adequate vertical clearance with respect to other rack-mounted instrumentation and that the location of the zero air module in the rack will permit easy access for service and maintenance. Mate the rail slide sections and install the analyzer in the rack. Ensure the analyzer slides smoothly on the rails into the rack and back out in the fully extended

position. Section 1.2 of the TAPI 701 Operation Manual lists the minimum required ventilation clearance for the instrument.

3.2.2 Pneumatic & Electrical Interconnections

(a) All materials employed for zero air delivery to the dilution calibrator shall be comprised of either FEP Teflon or type 316 stainless steel. All connections to the 701 or dilution calibrator for zero air delivery will be made using 1/4" O.D. (3/16" I.D.) FEP Teflon tubing and type 316 stainless steel fittings. Leak-tight compression fittings (e.g., Swagelok) are typically used for connecting tubing to port fittings. Zero air delivery lines should not exceed 10 feet in total length.

(b) Connect a length of 1/4" O.D. Teflon tubing from the “ZERO AIR OUT” port on the rear bulkhead of the 701 to the “ZERO AIR IN” inlet port on the rear bulkhead of the dilution calibrator.

(c) Screw the inlet filter into the “AIR IN” port. Hand tight is sufficient.

(d) Connect ¼” diameter tubing to the WATER DRAIN to conduct the occasional spurts of water away from the instrument rack. Connect the tubing to the ite exhaust manifold, where the water will be expelled to the outside atmosphere.

(e) Connect the supplied line voltage power cord to a convenient electrical outlet supplying 115VAC at 60Hz. At 115 VAC, 60 Hz, the 701 draws 3.5 Amps.

After the electrical and pneumatic connections are made, perform an initial functional check. Turn on the instrument. The front power light should come on. The cooling fan should start immediately. The compressor should start after a few seconds delay. The delay is to allow the control board to measure the local line frequency. After 30 to 60 seconds, the front panel pressure gauge should read 30 psig. The Model 701 is now producing clean dry air.

4. PREVENTIVE AND CORRECTIVE MAINTENANCE

In order to ensure the reliable operation of monitoring equipment, and a high degree of valid data capture, a preventive maintenance program is essential. For the Model 701 Zero Air Module, preventive maintenance activities are based on the guidance contained in the manufacturers' operating manual and Enviroplan Consulting's cumulative experience in conducting ambient air monitoring programs.

All maintenance performed must be entered in a chronological format in the site logbook and instrument maintenance log (see Form 8-1 at the end of this SOP). The instrument must be identified by make, model and serial number. Each entry must be dated and signed by the network operator.

The following maintenance should be performed on the 701:

(a) The 701 cooling fan, cooling coil and compressor fan inlet should be visually inspected and cleaned as necessary every three months. These tasks may have to be performed more often depending upon site conditions (e.g., excessively dirty surroundings). Remove any dust or dirt with a vacuum cleaner.

(b) The pneumatic tubing inside the 701 should be visually inspected whenever the cover is removed. Under vibration of the compressor, it is possible for some parts of the Teflon tubing to abrade against nearby objects. This is most likely to occur with the tubing directly attached to the compressor. Check to see if any signs of wear or abrasion are present, and if so, re-dress the tubing. If any section of tubing appears to be heavily abraded, remove and replace it.

(c) The charcoal scrubber should be replaced annually. Refer to Section 5.4 of the Model 701 Operation Manual for the procedure to replace the charcoal scrubber.

(d) The NO scrubber should be replaced annually. Refer to Section 5.5 of the Model 701 Operation Manual for the procedure to replace the NO scrubber. The canister should be refilled with Purafil®.

(e) The CO scrubber should be replaced when it becomes contaminated. Refer to Section 5.6 of the Model 701 Operation Manual for the procedure to replace the CO scrubber. Use caution as the CO scrubber will be hot.

(f) It is unlikely that the regenerative scrubber should ever need service. Should the molecular sieve become contaminated by oil or other external contaminants the scrubber will need to be cleaned and recharged. Refer to Section 5.9 of the Model 701 Operation Manual for the procedure to service the regenerative scrubber.

(g) The particulate filter on the rear panel should be replaced annually or as needed.

Table 4-1: Preventative Maintenance Schedule for the M701Zero Air Module

ITEM	ACTION	FREQUENCY	M701 MANUAL SECTION
Charcoal scrubber	Replace scrubber material	Annually	Section 5.4
NO scrubber	Replace scrubber material with Purafil®	Annually	Section 5.5
CO scrubber	Replace scrubber	When contaminated	Section 5.7
Regenerative Drier	Clean	When contaminated	Section 5.9
Particulate Filter on Rear Panel	Replace	Annually or as needed	Section 1.3
Pneumatic tubing	Inspect Replace	Whenever cover opened As needed	Section 5.3
Interior of M701	Clean	Every three months or as needed	Section 5.2

5. TROUBLESHOOTING

The Model 701 is designed utilizing a modular approach. The internal components of the instrument are grouped into replaceable subassemblies to facilitate fault isolation and correction. Chapter 6 ("Troubleshooting") in the Operation Manual should assist the field operator in identifying the malfunctioning component or module. The faulty module can then be replaced, thus returning the instrument to operation as soon as possible. The defective module can then be repaired by a technician familiar with the mechanical aspects or electrical principle involved in its operation.

A digital multimeter capable of resolving 1 mV is recommended for troubleshooting the Model 701 Zero Air Module.

A supply of common parts is typically a part of the network inventory. This parts stock is determined by repair history for the model in use. If the model incorporates any expendable or short-life components (recommended replacement frequency of one year or less), they are normally included as part of the network inventory, thus minimizing down time of the instrument.

In all circumstances, failure or malfunction of the instrument is to be reported promptly to the field supervisor and the Project Manager. A Non-Conformance/Corrective Action plan should be developed and implemented to resolve the problem as quickly as possible, so as to minimize any associated data loss (see Section C of the QAPP).

All actions associated with servicing or repairing the instrument will be summarized in the site logbook. A similar synopsis should appear in the "comments" section of the analyzer routine check form.

FORM 5-1: INSTRUMENT MAINTENANCE LOG

Mfgr:	Model:	S/N:

Date of Maintenance	Maintenance Type & Tech Initials		Maintenance Performed (Describe)	Instrument In Use At (Network and Site)
	Preventive	Corrective		